

Prompt Gamma Analysis of RFETS and LLNL Items

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NMT-11

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Prompt Gamma Studies

- Acknowledgement
 - Lynn Foster
 - Ric Mason
 - Larry Peppers
 - Paul Oppedal

Topics

- Introduction
- Analysis Methods
- Prompt Gamma Results
- Analysis of Furnace 5 Failure
- Conclusion

Introduction

- In the past, working with radioactive containers was costly, time consuming and put people a risk of radiation uptake due to destructive analysis.
- Prompt Gamma offers a method of non-destructive analysis through self-interrogation by alpha particles.
- This method is fast, safe, and inexpensive since the analysis can be done on sealed containers.



Current Focus

Identify cans containing high concentrations of impurities that are potentially corrosive or could lead to gas generation inside the 3013 containers leaving the Plutonium Stabilization and Packaging System.

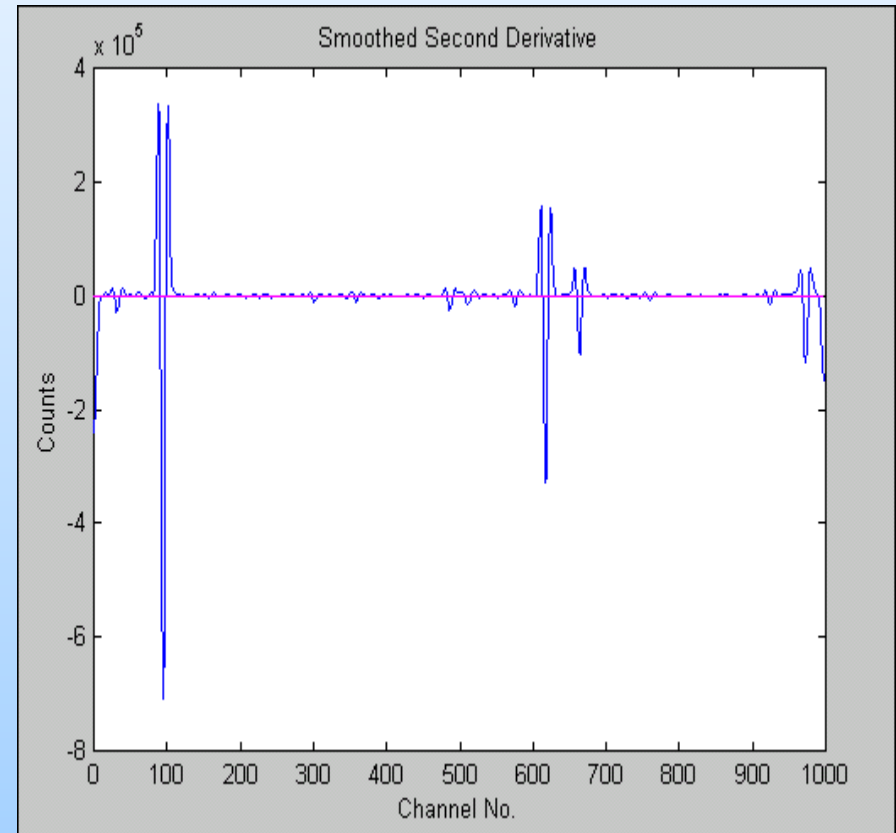
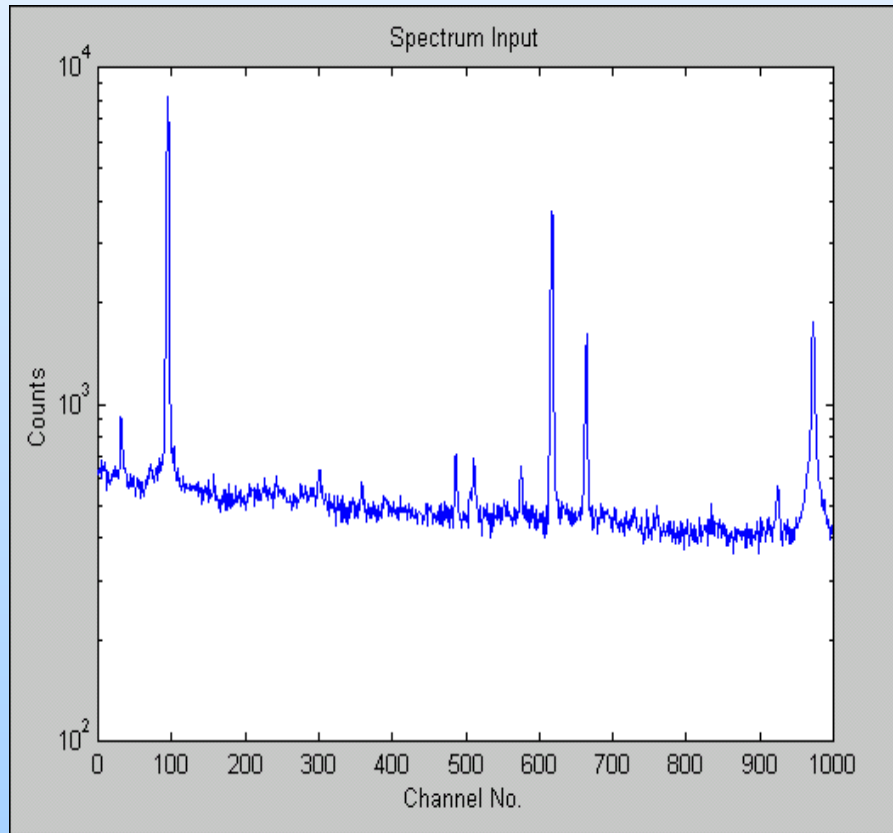
Elements of interest: Al, Be, Cl, F, K, Mg, Na, Si

Analysis Methods

- **Maestro Multi-channel Analyzer**
 - Calibrates channel data, locates and identifies peaks
 - User defines a region of interest (ROI), and the peak area is determined for the peak in that region
 - Cannot analyze broad, high-energy peaks
 - Insufficient output generation
- **Prompt Gamma Analysis Software**
 - Interactive display designed using Matlab®
 - Reads, plots, and calibrates channel data
 - Locates peaks using the Generalized Second Derivative Method and determines the net counts
 - Can analyze broad, high energy peaks
 - Identifies peaks using library of alpha-induced reactions
 - Lists all possible interferences
 - Creates tables and graphs for MIS database

Analysis Methods

Peak Search Routine



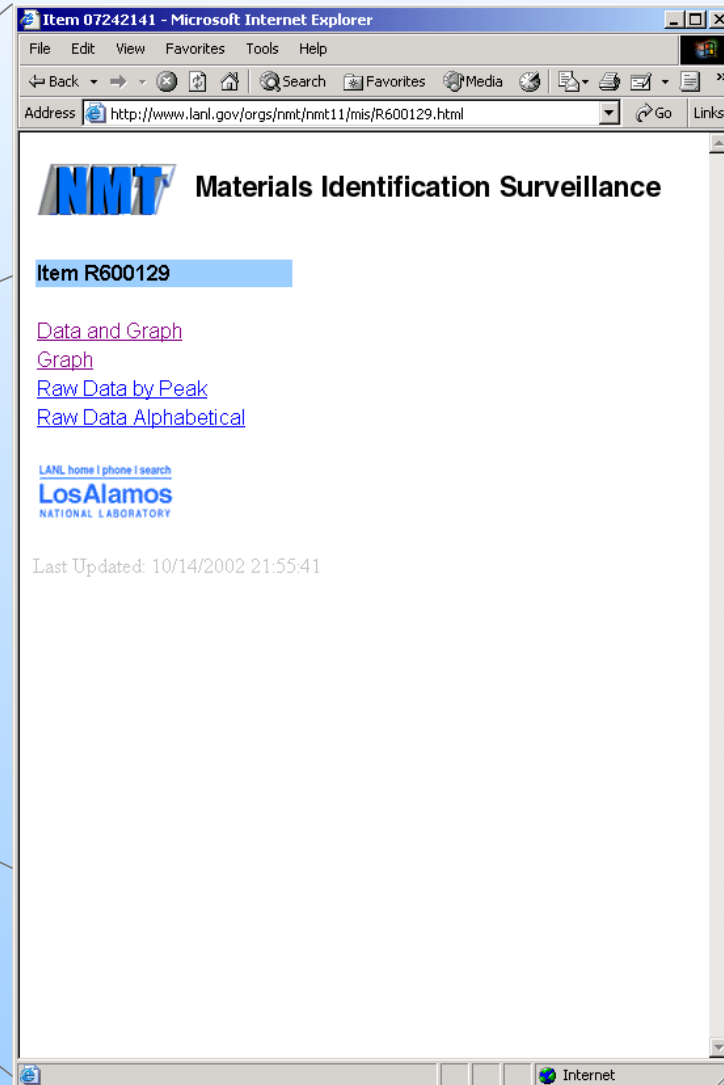
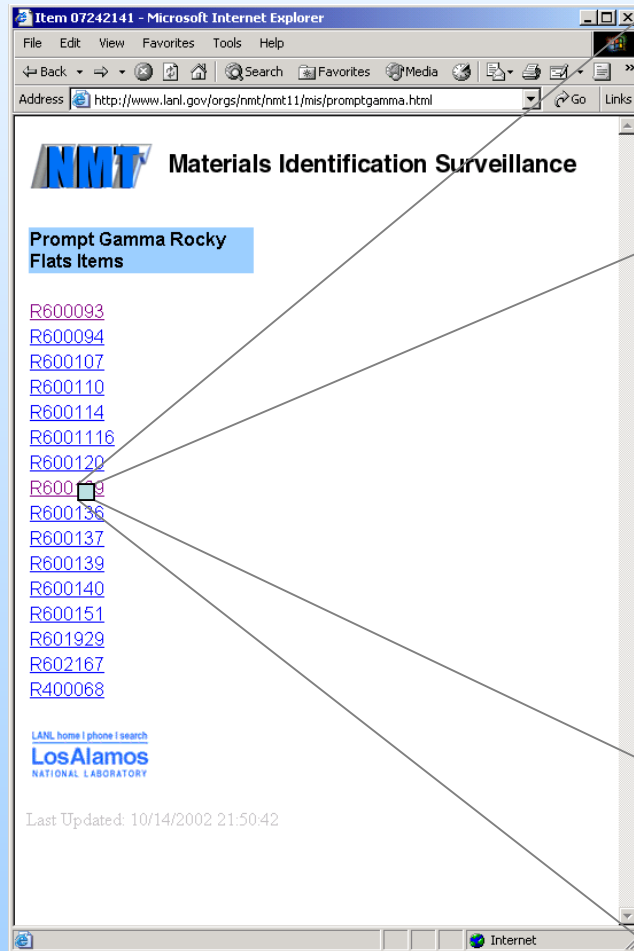
Analysis Methods

- Most elements are positively identified in the sample by their corresponding primary peak.

Element	Primary Peaks (keV)	Secondary Peaks (keV)		
Al	2236	1263	3498	2476
Be	4439	3928	3417	
Cl	2168	1146		
F	1275	891	1236	2081
K	1524			
Mg	1273	1014	2028	2839
Na	1808	1130	2132	2938
Si	2235	1266	1213	1779

- Elements such as F, Mg, Al, and Si have interferences and require the primary and one or more secondary peaks for positive identification.

Prompt Gamma Results on Web



Prompt Gamma Results on Web

Item Summary



Materials Identification Surveillance

Item **R600129** **11/8/2001**

Prompt Gamma Results										
	# pres	Enrgy	Counts	Rel int	Enrgy	Counts	Rel int	Enrgy	Counts	Rel int
Aluminum	2/21				1014*	184	5.5	1453	48	3.1
Beryllium	3/3	4440*	25	100	3928*	32	50	3417*	23	25
Chlorine	1/6									
Chromium										
Copper	2/4	1115	81	5.8	962*	130	24			
Fluorine	6/20				1274*	417	18.8			
Iron	2/7	847	944	84.3	368*	4668	3.6			
Magnesium	4/11	1014*	184	55.2	1274*	417	100	1778*	129	58.6
Potassium										
Sodium	1/19	1809	34	100						
Silicon	2/8				1778*	129	4.3	1274*	417	3.2
Tantalum										

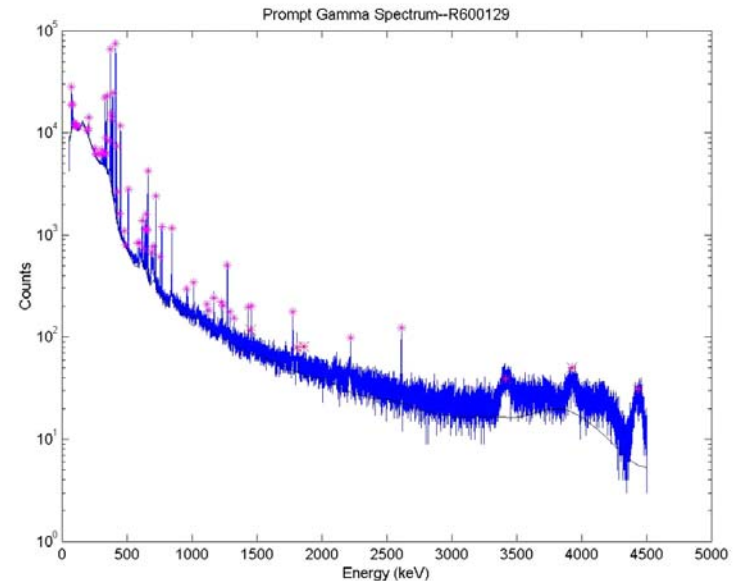
* Denotes possible overlap of peaks and uncertainty in identification.

—Grayed-out numbers represent small peaks of low significance

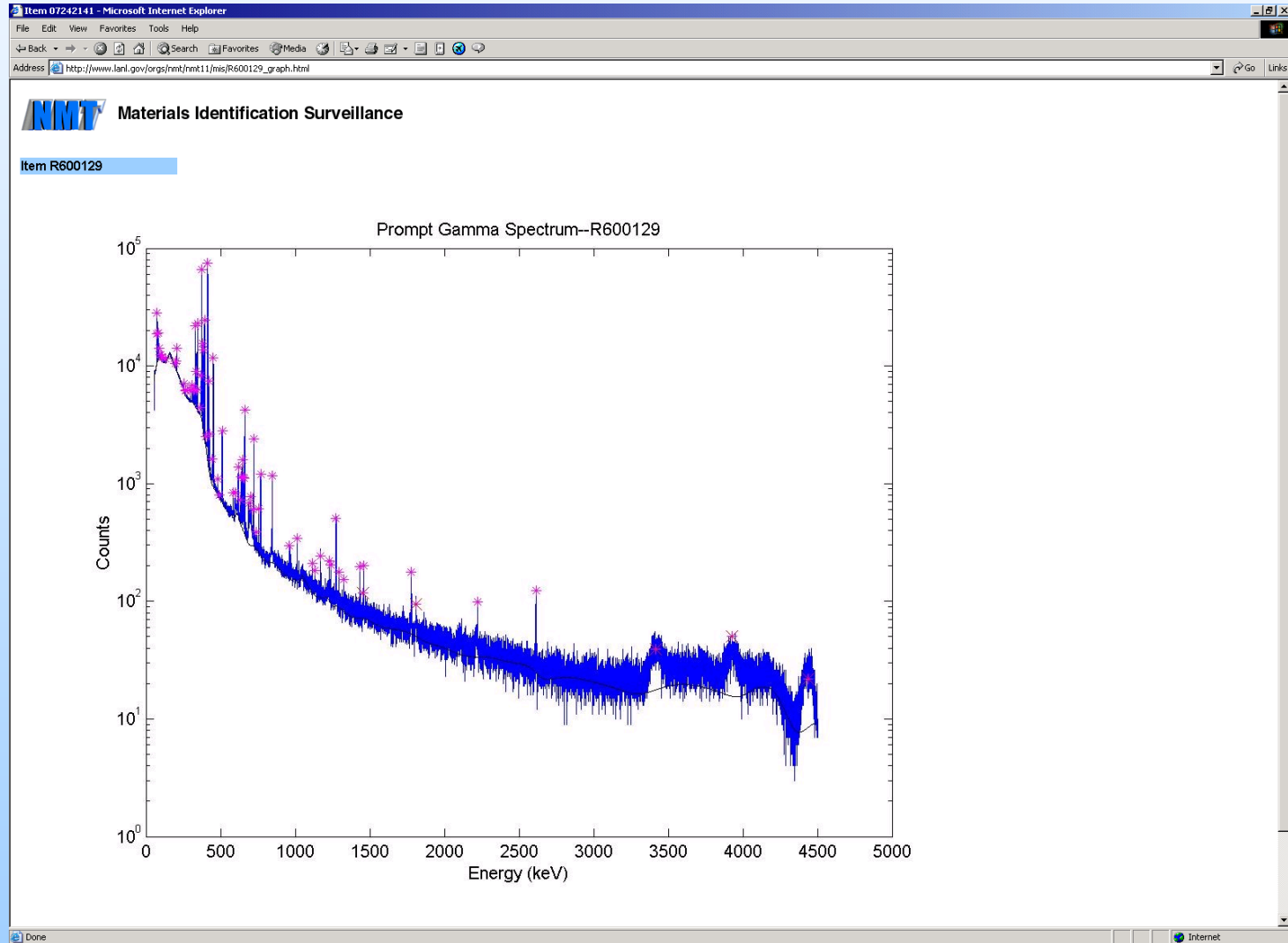
—blanks represent elements not identified by prompt gamma

Conclusions:

1. Beryllium present (4440)
2. Copper present (1115)
3. Magnesium present (1014, 1274)
4. Sodium present (1809)
5. Aluminum possible although missing 2236
6. Fluorine possible (1274) although missing second peak 891
7. Silicon possible although missing 2235



Prompt Gamma Results on Web



Prompt Gamma Results on Web

Raw Data Reports

http://www.lanl.gov/orgs/nmt/nmt11/mis/R600129_alpha.xls - Microsoft Internet Explorer

File Edit View Insert Format Tools Data Acrobat Go To Favorites Help

Address http://www.lanl.gov/orgs/nmt/nmt11/mis/R600129_alpha.xls

A1 Peak Summary

A	B	C	D	E	F	G	H	I
1	Peak Summary							
2	Label	Peaks/Total	Energy	Rel Cts	Rel Inten	SS/F	SS	
4	Am-241	15/43	98.4*	1028	**	3070	121072	
5			103.4*	860	**	6350	111268	
6			203.4*	1836	**	21888	187010	
7			207.8*	5373	**	35637	583401	
8			311.5*	1921	**	20560	201442	
9			332.7*	17607	**	65288	1796319	
10			336.0*	4530	**	45593	335042	
11			340.9*	1925	**	15395	178214	
12			367.9*	4537	**	30001	418944	
13			399.5*	380	**	1002	24875	
14			451.2*	10808	**	34982	1175403	
15			632.3*	267	**	1100	20631	
16			652.1*	725	**	5327	68637	
17			662.0*	3872	**	23391	407835	
18			721.7*	2093	**	11580	223048	
19								
20								
21	Am-243	3/12	74.8*	17665	**	22407	1431274	
22			87.2*	2128	**	660	8885	
23			98.4*	1028	**	3070	121072	
24								
25								
26	B-10	1/11	769.0*	955	0.8	8641	91453	
27								
28								
29	Be-8	3/3	3417.3*	21	25	7	42	
30			3928.4*	34	50	38	364	
31			4439.0*	14	100	57	357	
32								
33								
34	Bi-208	3/6	72.3*	8346	**	14576	306103	
35			74.8*	17665	**	22407	1431274	
36			2614.3*	98	**	1383	8636	

R600129-PeakSummary-alpha/ Unknown Zone

http://www.lanl.gov/orgs/nmt/nmt11/mis/R600129_peak.xls - Microsoft Internet Explorer

File Edit View Insert Format Tools Data Acrobat Go To Favorites Help

Address http://www.lanl.gov/orgs/nmt/nmt11/mis/R600129_peak.xls

A18 1115.4

A	B	C	D	E	F	G	H	I
1	Peak Summary							
2	Act. Energy	Hit #	Energy	Label	Counts	Rel. Intensity	SS/F	SS
3	688.4	1	687.6	Pu-240	372.8		3462	29782
4	688.4	2	687.7	Np-236	372.8		3462	29782
5	703.3	1	702.6	Nb-94	481.2		5053	37815
6	717.3	1	717.7	Pu-239	307.6		1389	23407
7	721.7	1	722	Am-241	2093.3		11580	223048
8	721.7	2	722	Ti-208	2093.3		11580	223048
9	755.8	1	755	Mg-26	352.8		9	2917
10	769	1	768	B-10	954.9	0.8	8641	91453
11	769	2	768.4	Ra-226	954.9		8641	91453
12	769	3	769.3	Pu-239	954.9		8641	91453
13	846.5	1	846.8	Fe-56	959.9	84.3	4788	99296
14	962	1	962.1	Cu-63	135.1	24	1323	15080
15	962	2	962.8	Cm-242	135.1		1323	15080
16	1014.2	1	1014.5	Al-27	194.3	5.5	1241	20424
17	1014.2	2	1014.5	Mg-24	194.3	55.2	1241	20424
18	1115.4	1	1115.5	Cu-65	88.8	5.8	508	5833
19	1238	1	1238	Bi-214	109.5		1011	10550
20	1274	1	1273.3	Mg-26	417.2	100	4683	43681
21	1274	2	1273.3	Si-29	417.2	3.2	4683	43681
22	1274	3	1274.6	F-19	417.2	18.8	4683	43681
23	1453.3	1	1454	Al-27	46.3	3.1	199	2426
24	1460.4	1	1460.8	Cl-37	128.5	1.8	2794	12494
25	1460.4	2	1460.8	K-40	128.5		2794	12494
26	1778.2	1	1778.9	Mg-25	124	58.6	411	7547
27	1778.2	2	1778.9	Si-28	124	4.3	411	7547
28	1809	1	1808.7	Na-23	43.5	100	70	824
29	2223.3	UNABLE TO IDENTIFY PEAK			65.4		496	4120
30	2614.3	1	2613.5	O-17	98.2	0.1	1383	8636
31	2614.3	2	2614	Bi-208	98.2		1383	8636
32	2614.3	3	2614	U-232	98.2		1383	8636
33	2614.3	4	2614.5	Ti-208	98.2		1383	8636
34	3417.3	1	3417.2	Be-8	21.4	25	7	42
35	3928.4	1	3928.2	Be-8	34.4	50	38	364
36	4439	1	4439.2	Be-8	13.5	100	57	357

R600129-Peak_Summary-peak/ Unknown Zone

Prompt Gamma Results on Web

Prompt Gamma Results Summary

Filename	Content													Comments
	Al	Be	Cl	Cr	Cu	F	Fe	Mg	K	Na	Si	Ta		
R400068.Chn						F		Mg						
R600093.Chn													no positive detection	
R600094.Chn								Mg						
R600107.Chn						F		Mg						
R600110.Chn					Cu	F		Mg						
R6001116.Chn						F		Mg						
R600114.Chn													no positive detection	
R600120.Chn													no positive detection	
R600129.Chn		Be			Cu			Mg		Na				
R600136.Chn													no positive detection	
R600137.Chn													no positive detection	
R600139.Chn								Mg						
R600140.Chn								Mg						
R601929.Chn						F		Mg						
R602005.Chn	Al	Be			Cu			Mg		Na	Si		Very large Be-peaks, missing Pu pks > 500 keV	
R602167.Chn								Mg						
R602729.Chn		Be			Cu			Mg					Very large Be-peaks, missing Pu pks > 500 keV	
R602787.Chn	Al		Cl					Mg			Si			

Prompt Gamma Results on Web



Materials Identification Surveillance

Item **R602005**

8/22/2002

Prompt Gamma Results										
	# pres	Energy	Counts	Rel int	Energy	Counts	Rel int	Energy	Counts	Rel int
Aluminum	4/21	2235*	409	100	709*	3655	27.1	1333	76	0.9
Beryllium	3/3	4439	5947	100	3928	5526	50	3417	8049	25
Chlorine	/6									
Chromium	/3									
Copper	2/4	1115	671	5.8	962*	936	24			
Fluorine	5/20				1274*	904	18.8			
Iron	1/7	846	8240	84.3						
Magnesium	4/11	1014	1666	55.2	1274*	904	100	756	4991	9
Potassium	1/3				312*	38395	20			
Sodium	1/19	1809	491	100						
Silicon	4/8	2234*	409	29.9	1722	123	***	1778*	799	4.3
Tantalum	/3									

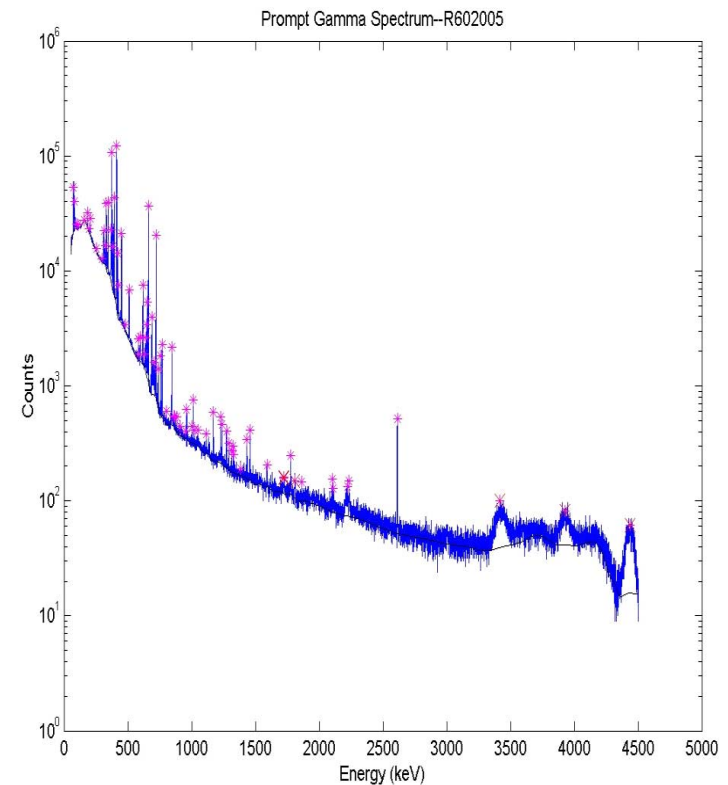
* Denotes possible overlap of peaks and uncertainty in identification.

—Grayed-out numbers represent small peaks of low significance

—blanks represent elements not identified by prompt gamma

Conclusions:

1. Beryllium present (4439)
2. Copper present (1115)
3. Magnesium present (1014, 1274)
4. Sodium present (1809)
5. Aluminum or Silicon or both present -- (2234, and each has additional characteristic peaks (1333 Al and 1722 Si))
6. Fluorine possible (1274) although missing (891)



Prompt Gamma Results on DB

- Analyzed and unanalyzed data will also be put onto the ISP database.
- They will be passed on to the rest of the sites.
- Will be helpful to future surveillance and research projects.

Furnace 5 Failure



- Furnace sustained severe damage to support stand and right wall behind element.
- Exterior of furnace shows discoloration above door frame due to escaping gases.

Furnace 5 Failure

- The damage was discovered shortly the material for can R601284 was calcined.
- It was initially theorized that corrosive gases from this batch, released during calcination, were a direct cause of the damage to the furnace stand.
- Prompt Gamma showed only small amounts of Na and Mg in R601284.

Furnace 5 Failure

- RFETS then made a request for analysis of items that went into the furnace for 2 months prior to furnace failure.
- We pulled from the DB the last 30 items that fed into furnace 5 prior to failure.
- We researched feed combinations and IDC's looking for anything obvious.
- Used software to analyze individual items looking for any type of corrosive materials that prompt gamma could see.

Furnace 5 Results

- Most spectra contained small Mg peaks at 1274 keV and 1014 keV.
- Na, F, and Be were also detected in a few cans.
- Found no relationship between IDC and impurities found in sample.
- Cl not detected in any cans.

IDC	Description
057	Pu oxide awaiting specification analysis. Includes metal turnings, floor sweepings, fines, etc.
060	High purity Pu oxide
061	Pu oxide with high impurities
U61	Pu / Enriched U oxide < 10,000 ppm Enriched U
Y61	Pu / Enriched U oxide > 10,000 ppm Enriched U

Feed IDC(s)	Item	LOI	Positive Detection
057	R600333	0.073	Mg
	R600422	0.100	Mg
	R600819	0.095	Mg
	R601010	0.116	Mg
057/061	R600517	0.020	F, Mg
060	R600317	0.048	Mg
	R600350	0.038	Mg
	R600442	0.024	Mg
	R600802	0.108	F, Mg
	R600812	0.070	Mg
	R600914	0.028	--
	R600927	0.130	Mg
	R600967	0.076	Mg
	R601063	0.090	Mg
	R601106	0.106	Mg
	R601146	0.080	Mg, Na
060/061	R600340	0.210	F, Mg
	R601046	0.000	Mg
	R601142	0.075	Mg
	R601208	0.090	F, Mg
060/U61/Y61	R600385	0.106	Mg, Be
061	R600357	0.032	Mg, Be
	R600785	0.118	F, Mg
	R601011	0.105	Mg
	R601284	0.230	Mg, Na
U61	R600263	0.074	--
	R600477	0.114	Mg
U61/Y61	R601082	0.089	Mg, Na
Y61	R600931	0.112	Mg

Furnace 5 Results

- The prompt gamma results suggest several possible causes for the failure.
 1. Corrosive material evaporated during calcination and is no longer detectable with prompt gamma.
 2. Corrosive material is not detectable with prompt gamma.
 3. Damage occurred because of other causes such as the sensitization of 304 stainless steel that occurs due to repeated heating above 425° C.
 4. Supported RFETS working notion that Cl, F are not the problem with these particular items.

Limitations of Prompt Gamma

- Prompt Gamma Analysis yields only qualitative results for RFETS data.
- More research is required to obtain quantitative results due to the following limitations:
 - Lack of Chemical Data
 - Non-Homogeneous System
 - Limited Pu Contact
 - Limited Range of Alpha Particles
 - Varying Particle Size
 - Interference in Spectrum Data
 - Varying Conditions – Measurement Time, Material Composition, Distance, and Shielding
 - Lack of Replication (1X or Reruns)

Future Work

- Continued Analysis of RFETS, LANL and any other sites Items.
- Continued refinement of analysis software to determine content of storage containers.
- Develop a model for the production and detection of gamma rays in pure materials.
- Design standards: Pu oxide mixtures with known particle size and chemical content.
- Determine the relationship between the standard mixtures and pure compounds.

Prompt Gamma

- Any questions?